



US010654466B2

(12) **United States Patent**
Ogawa

(10) **Patent No.:** **US 10,654,466 B2**

(45) **Date of Patent:** **May 19, 2020**

(54) **HYBRID VEHICLE**

2240/54 (2013.01); B60L 2260/28 (2013.01);

B60W 2300/18 (2013.01); B60W 2510/244

(71) Applicant: **Toyota Jidosha Kabushiki Kaisha,**
Toyota-shi, Aichi-ken (JP)

(2013.01); B60W 2710/244 (2013.01); B60Y

2200/92 (2013.01)

(72) Inventor: **Yuki Ogawa,** Toyota (JP)

(58) **Field of Classification Search**

CPC B60W 20/13; B60W 10/08; B60W 10/26;

B60W 30/182; B60W 50/082; B60K

1/02; B60K 6/28; B60K 6/365; B60K

6/445

(73) Assignee: **Toyota Jidosha Kabushiki Kaisha,**
Toyota-shi, Aichi-ken (JP)

USPC 180/65.21, 65.265

See application file for complete search history.

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(56) **References Cited**

(21) Appl. No.: **16/273,446**

U.S. PATENT DOCUMENTS

(22) Filed: **Feb. 12, 2019**

8,452,471 B2 * 5/2013 Wilde B60W 10/06

701/22

(65) **Prior Publication Data**

8,849,485 B2 * 9/2014 Christ B60L 15/2045

701/22

US 2019/0248357 A1 Aug. 15, 2019

(Continued)

(30) **Foreign Application Priority Data**

FOREIGN PATENT DOCUMENTS

Feb. 13, 2018 (JP) 2018-023023

JP 2016159848 A 9/2016

(51) **Int. Cl.**

Primary Examiner — John D Walters

B60W 10/08 (2006.01)

(74) *Attorney, Agent, or Firm* — Dinsmore & Shohl LLP

B60W 10/26 (2006.01)

B60W 20/00 (2016.01)

B60W 30/182 (2020.01)

B60W 20/13 (2016.01)

B60K 6/445 (2007.10)

B60K 1/02 (2006.01)

B60K 6/28 (2007.10)

B60K 6/365 (2007.10)

(Continued)

(57) **ABSTRACT**

A hybrid vehicle includes a controller. First control is control of an engine and a motor such that the hybrid vehicle travels by switching between a charge depleting mode and a charge sustaining mode. Second control is control of the engine and the motor such that the hybrid vehicle travels in accordance with a travel plan in which the charge depleting mode or the charge sustaining mode is assigned to each travel section of a travel plan route to a destination. The controller controls the engine and the motor such that a state of charge of an electric power storage device becomes higher in the charge sustaining mode in the second control than in the charge sustaining mode in the first control.

(52) **U.S. Cl.**

7 Claims, 7 Drawing Sheets

CPC **B60W 20/13** (2016.01); **B60K 1/02**

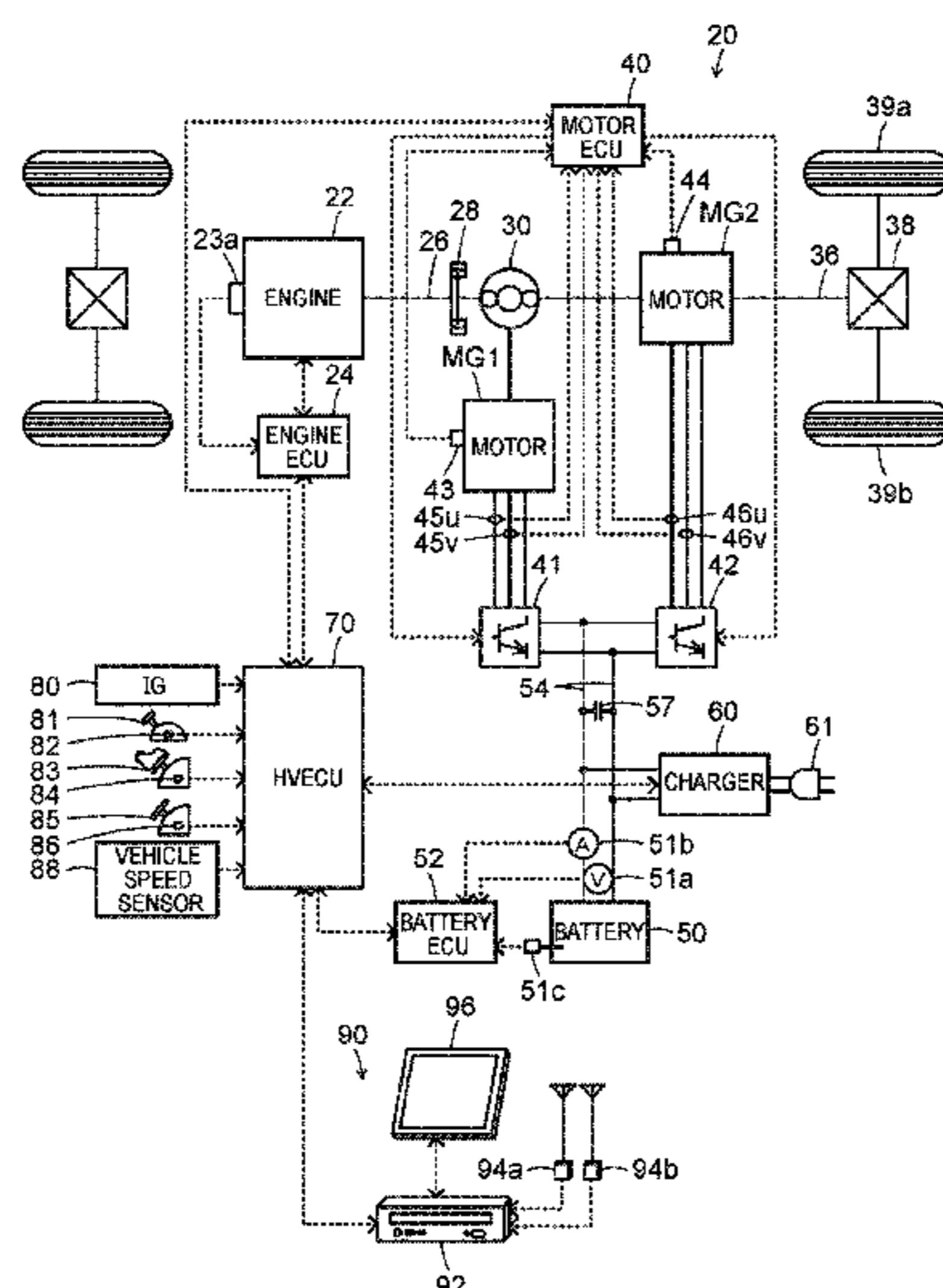
(2013.01); **B60K 6/28** (2013.01); **B60K 6/365**

(2013.01); **B60K 6/445** (2013.01); **B60W**

10/08 (2013.01); **B60W 10/26** (2013.01);

B60W 30/182 (2013.01); **B60W 50/082**

(2013.01); **B60K 6/46** (2013.01); **B60L**



- (51) **Int. Cl.**
B60W 50/08 (2020.01)
B60K 6/46 (2007.10)

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,099,695 B2 * 10/2018 Sawada B60W 10/08
2016/0257294 A1 9/2016 Morisaki

* cited by examiner

FIG. 1

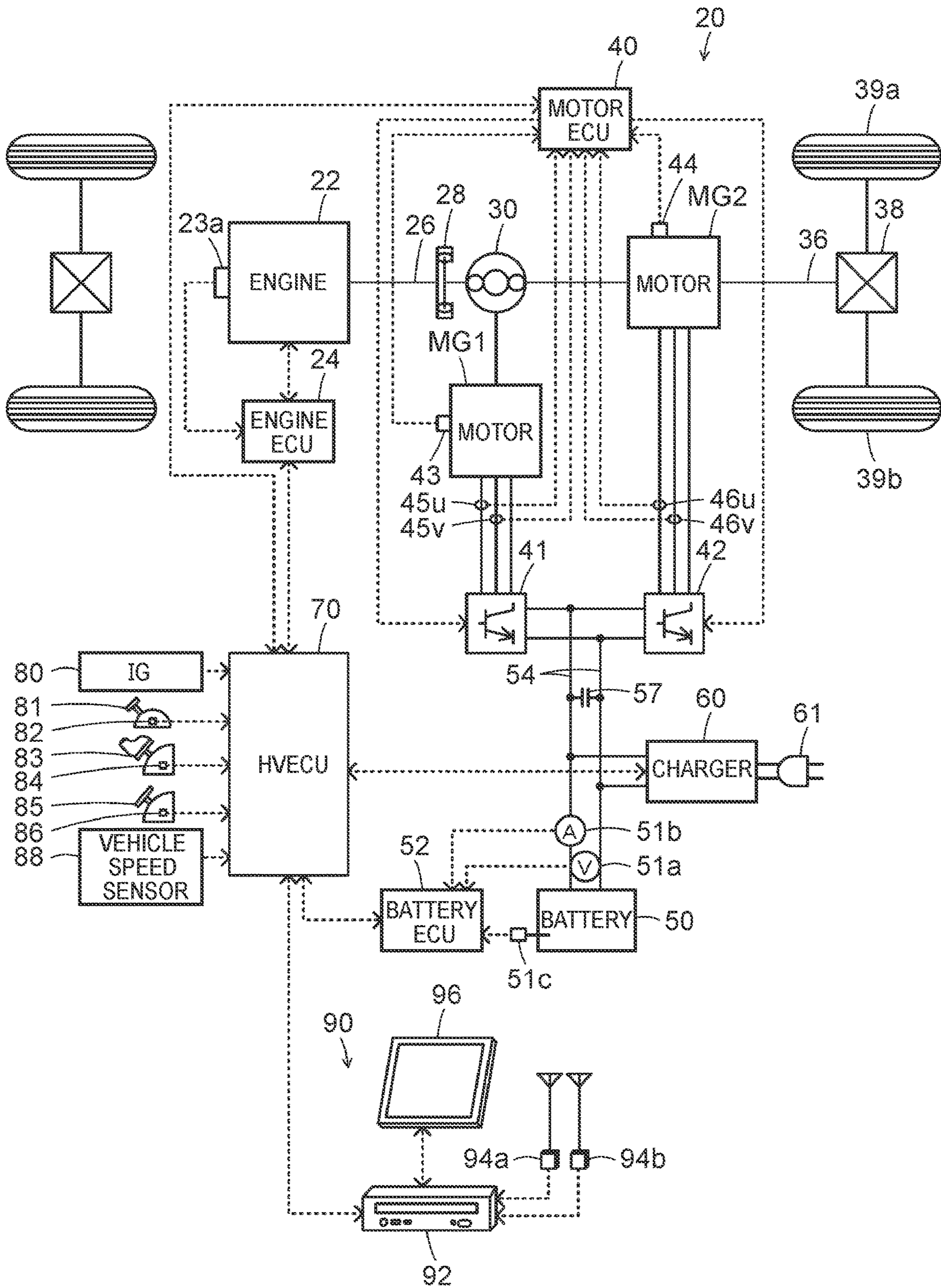


FIG. 2

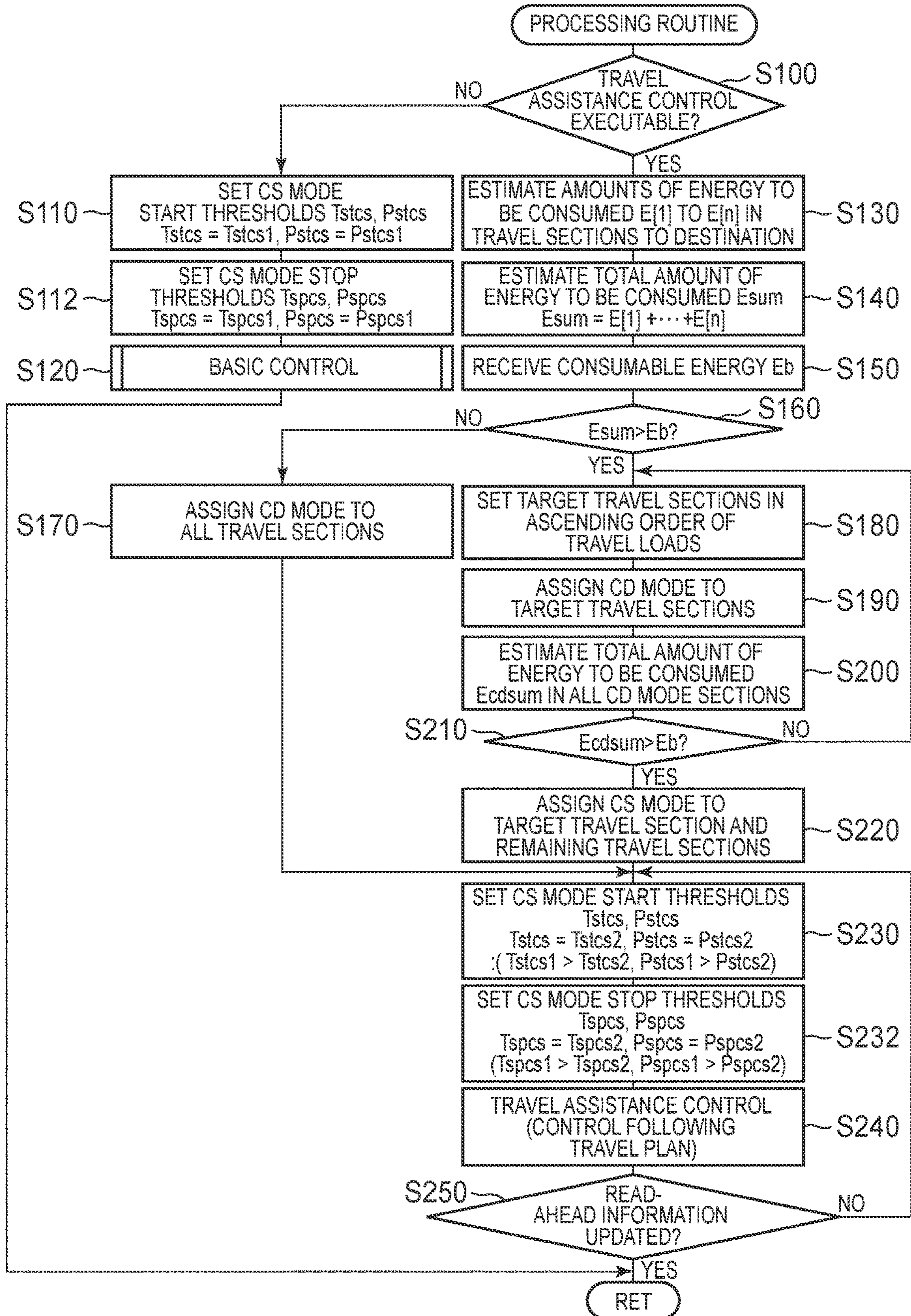


FIG. 3

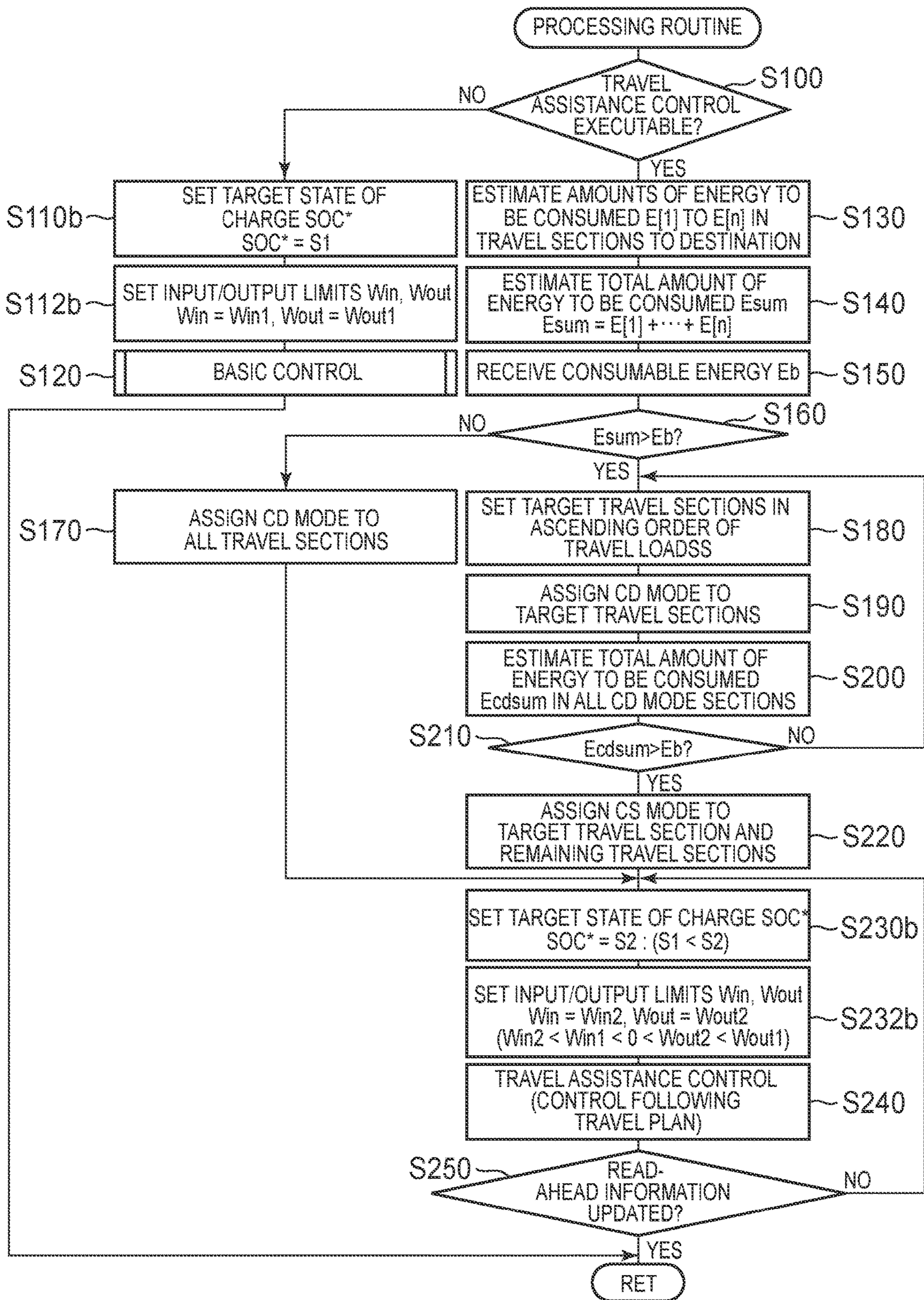


FIG. 4

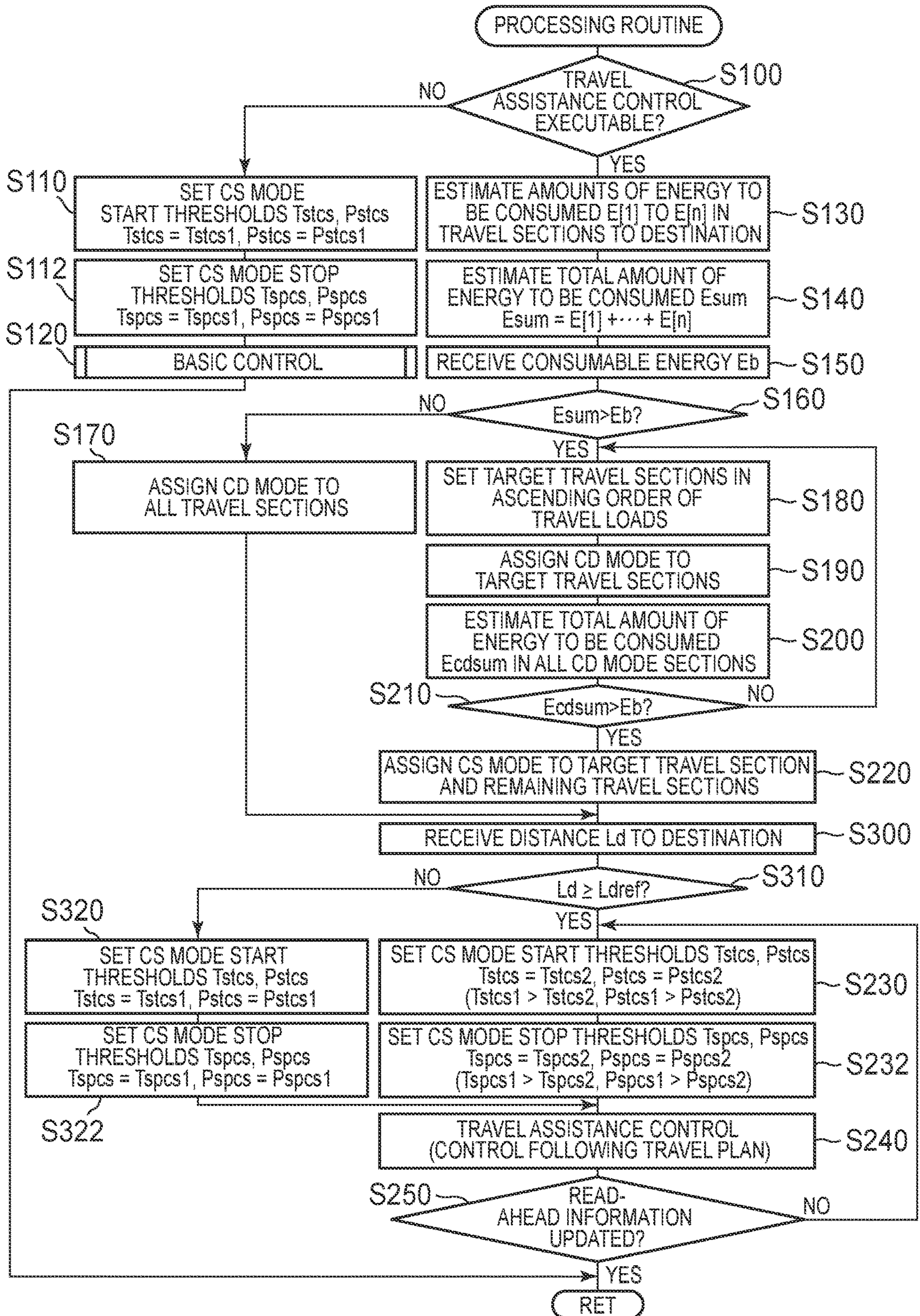


FIG. 5

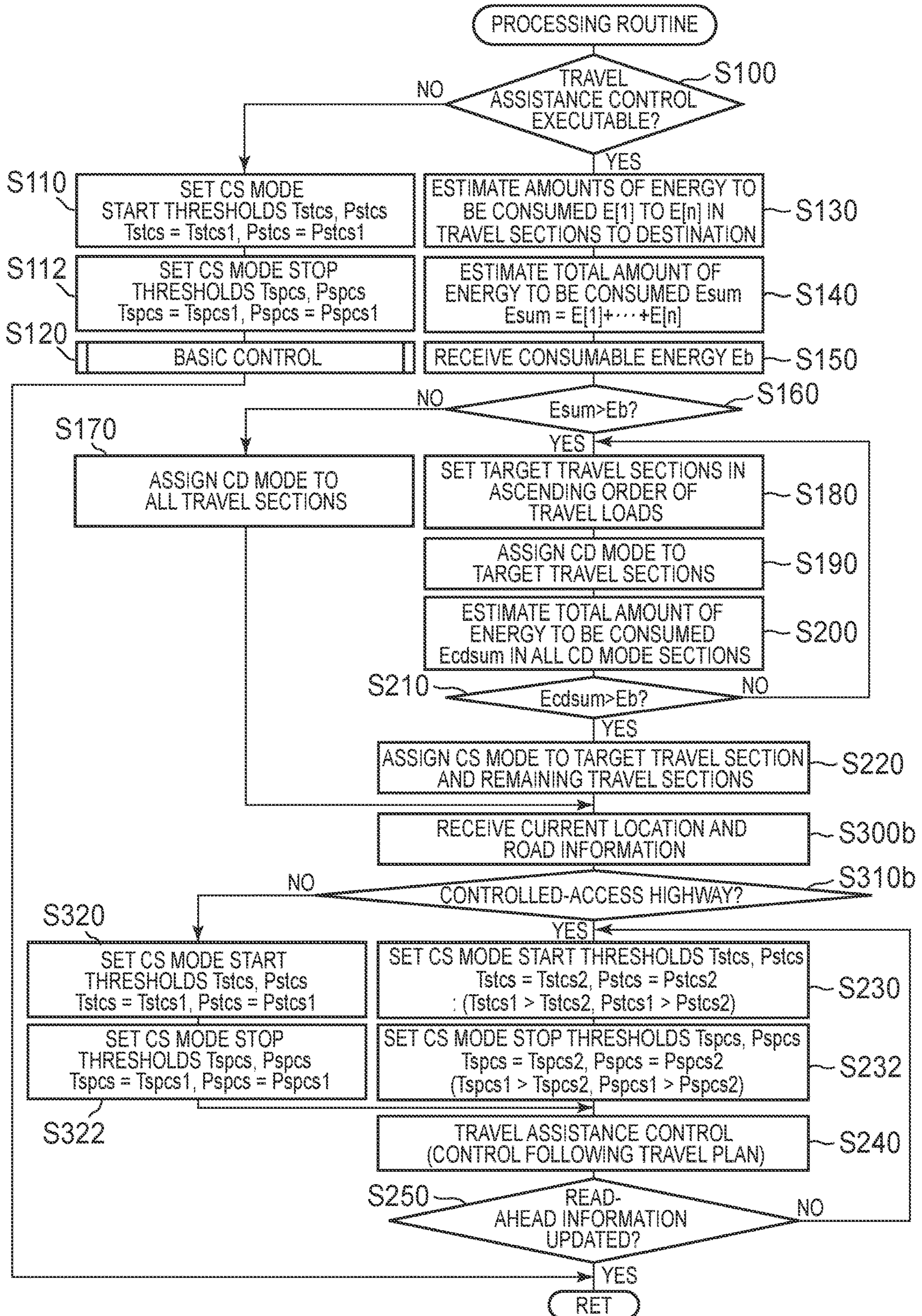


FIG. 6

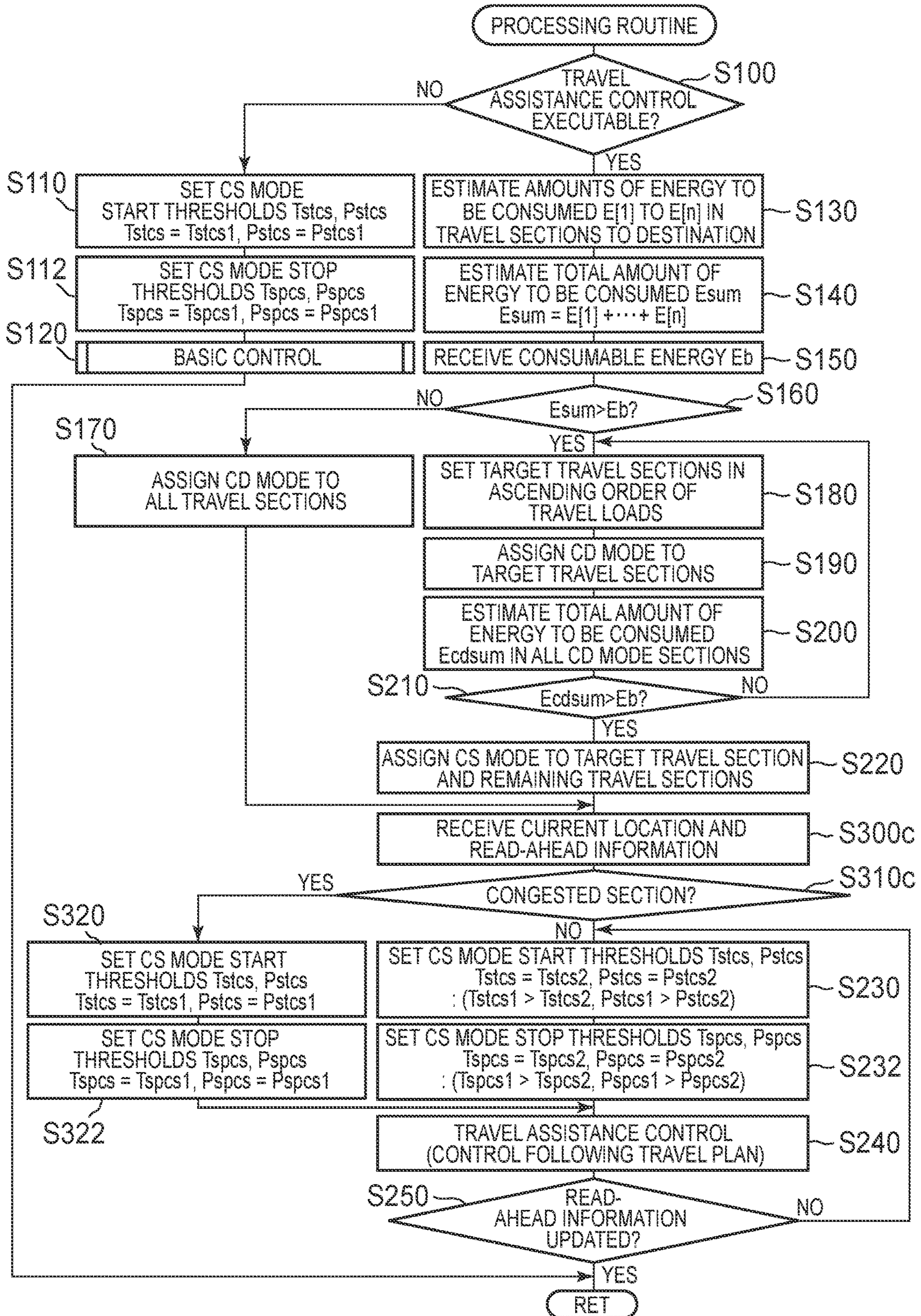


FIG. 7

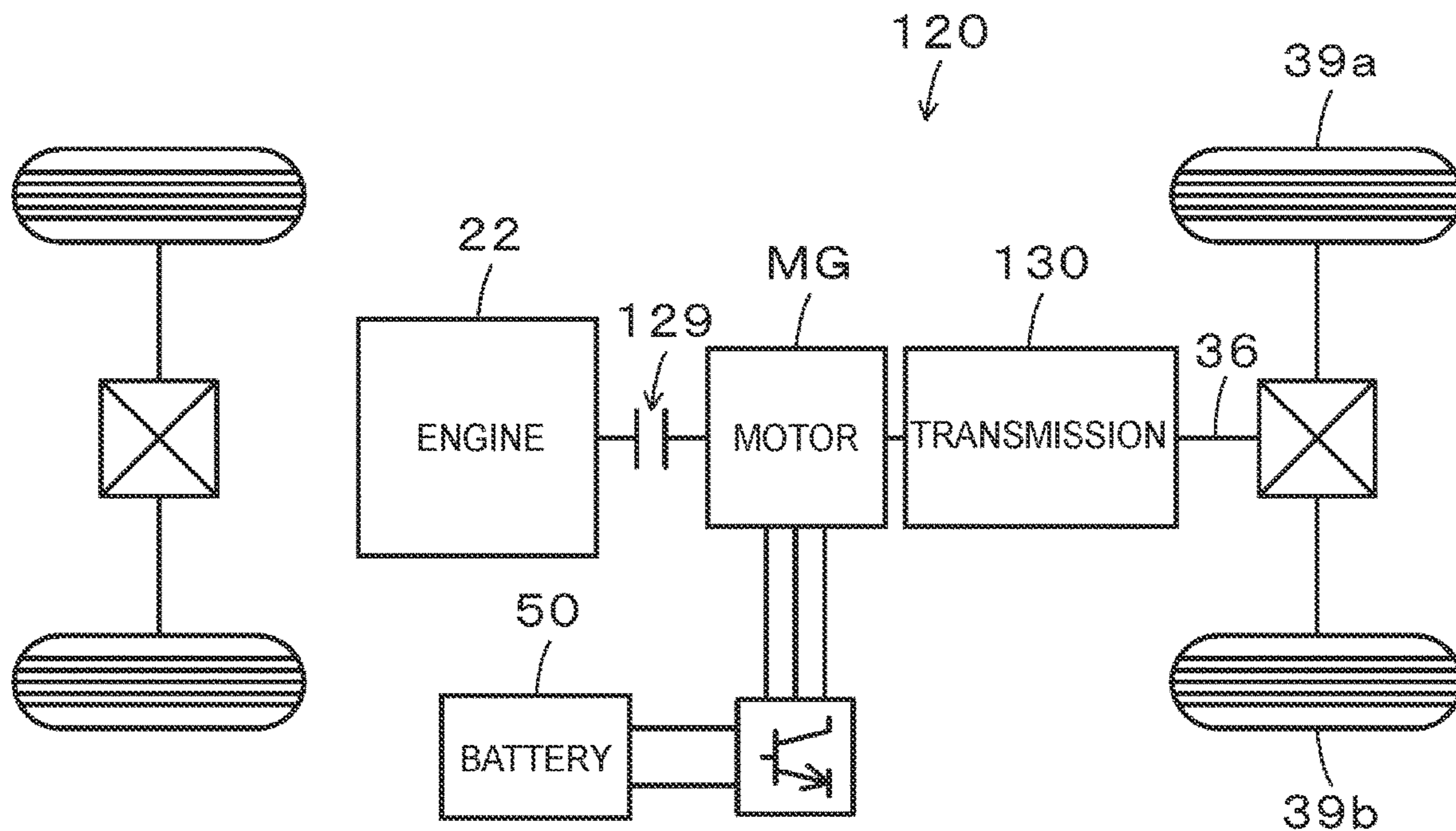
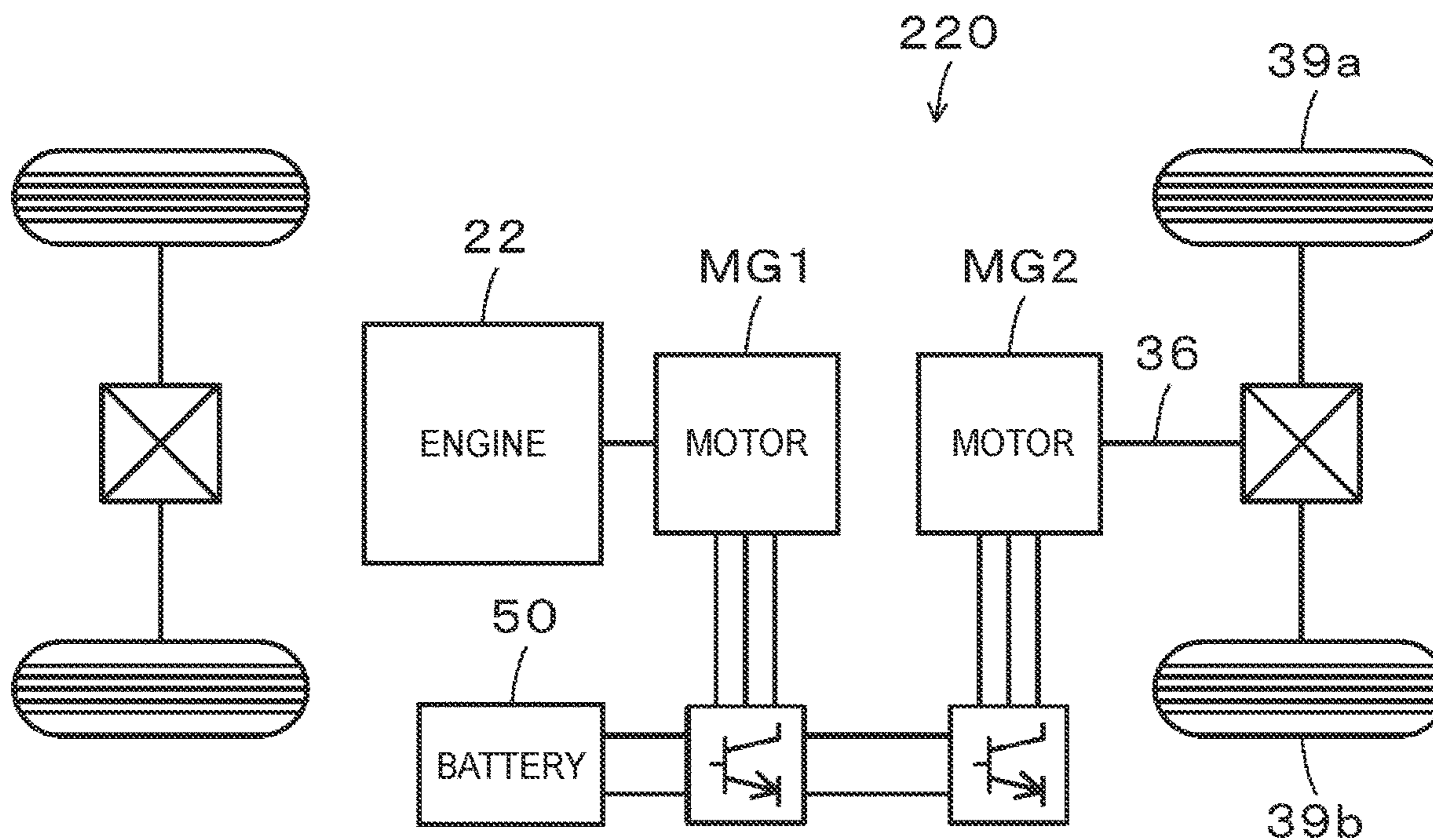


FIG. 8



1**HYBRID VEHICLE****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims priority to Japanese Patent Application No. 2018-023023 filed on Feb. 13, 2018, which is incorporated herein by reference in its entirety including the specification, drawings and abstract.

BACKGROUND**1. Technical Field**

The disclosure relates to a hybrid vehicle and, in particular, to a hybrid vehicle that includes an engine, a motor, and an electric power storage device.

2. Description of Related Art

Conventionally, as a hybrid vehicle of this type that includes an engine, a motor, and a battery that stores electric power from the motor and supplies electric power to the motor, a hybrid vehicle in which a charge depleting (CD) mode or a charge sustaining (CS) mode is assigned to each travel section of a travel plan route to a destination on the basis of a travel load so as to create a plan and in which the engine and the motor are controlled to realize travel in accordance with the plan has been proposed (for example, see Japanese Patent Application Publication No. 2016-159848 (JP 2016-159848 A)). In such a hybrid vehicle, in the case where a travel section in which the travel load cannot be calculated is present upon creation of the plan, the CD mode is assigned to such a travel section. In this way, even when the travel section in which the travel load cannot be calculated is present, the plan can be created.

SUMMARY

In the above-described hybrid vehicle, in the case where a larger amount of energy (a larger electric power amount) of the battery than expected is consumed in the travel section in the CS mode, an amount of the energy of the battery that can be used later in the travel section in the CD mode becomes smaller than expected.

The disclosure provides a hybrid vehicle that suppresses an amount of energy of an electric power storage device capable of being used in a travel section in a CD mode from becoming smaller than expected in the case where the vehicle travels in accordance with a travel plan in which the CD mode or a CS mode is assigned to each of the travel sections of a travel plan route to a destination.

A hybrid vehicle of the disclosure is summarized as a hybrid vehicle including: an engine; a motor; an electric power storage device configured to store electric power from the motor and supply electric power to the motor; and a controller configured to execute first control when a specified condition is not satisfied and to execute second control when the specified condition is satisfied, the specified condition including such a condition that a destination has been set, the first control being control of the engine and the motor such that the hybrid vehicle travels by switching between a charge depleting (CD) mode and a charge sustaining (CS) mode, and second control being control of the engine and the motor such that the hybrid vehicle travels in accordance with a travel plan in which the CD mode or the CS mode is assigned to each travel section of a travel plan route to the

2

destination when the specified condition is satisfied, in which the controller is configured to control the engine and the motor such that a state of charge of the electric power storage device becomes higher in the CS mode in the second control than in the CS mode in the first control.

In this hybrid vehicle of the disclosure, when the specified condition including such a condition that the destination has been set is not satisfied, the first control is executed to control the engine and the motor such that the hybrid vehicle travels by switching between the CD mode and the CS mode. When the specified condition is satisfied, the second control is executed to control the engine and the motor such that the hybrid vehicle travels in accordance with the travel plan in which the CD mode or the CS mode is assigned to each of the travel sections of the travel plan route to the destination. In addition, in the CS mode in the second control, the engine and the motor are controlled such that the state of charge of the electric power storage device becomes higher than that in the CS mode in the first control. In this way, compared to the case where the same control as that in the CS mode in the first control is executed in the CS mode in the second control, the state of charge of the electric power storage device can be made high in the travel section in the CS mode in the second control. As a result, it is possible to suppress an amount of energy of the electric power storage device, which can be consumed in the following travel section in CS mode in the second control, from becoming smaller than expected. Here, the CD mode is a mode in which the state of charge of the electric power storage device is reduced. The CS mode is a mode in which the state of charge of the electric power storage device is maintained within a management range including a control center.

In such a hybrid vehicle of the disclosure, the controller may be configured to set a start threshold of the engine to be lower in the CS mode in the second control than in the CS mode in the first control. In this way, in the CS mode in the second control, a start of the engine is facilitated in comparison with the CS mode in the first control. Thus, the state of charge of the electric power storage device can be made high.

In addition, in the hybrid vehicle of the disclosure, the controller may be configured to set a stop threshold of the engine to be lower in the CS mode in the second control than in the CS mode in the first control. In this way, in the CS mode in the second control, a stop of the engine is impeded in comparison with the CS mode in the first control. Thus, the state of charge of the electric power storage device can be made high.

Furthermore, in the hybrid vehicle of the disclosure, in the CS mode in the second control, the controller may execute at least one of increasing a target charged/discharged amount of the electric power storage device to a charged side, increasing allowable charge electric power of the electric power storage device, and reducing allowable discharge electric power of the electric power storage device in comparison with those in the CS mode in the first control. In this way, in the CS mode in the second control, the state of charge of the electric power storage device can be made higher than that in the CS mode in the first control by increasing the target charged-discharged amount of the electric power storage device to the charged side.

In the hybrid vehicle of the disclosure, the controller may be configured to execute the same control as that in the CS mode in the first control in the case where a distance to the destination is shorter than a specified distance in the CS mode in the second control. In the case where the state of

charge of the electric power storage device is made high in the travel section in the CS mode when the distance to the destination is short, there is a possibility that the high state of charge of the electric power storage device cannot sufficiently be consumed in the travel section in the CD mode to the destination. In consideration of the above, the same control as that in the CS mode in the first control may be executed in the case where the distance to the destination is shorter than the specified distance in the CS mode in the second control.

In addition, in the hybrid vehicle of the disclosure, the controller may be configured to execute the same control as that in the CS mode in the first control in the case where a current location is not on a controlled-access highway in the CS mode in the second control. When the current location is not on the controlled-access highway, it is considered that, compared to the controlled-access highway, a travel load is low and there is a low possibility that a larger amount of the energy of the electric power storage device than expected is consumed in the travel sections in the CS mode and the CD mode. Accordingly, in the case where the state of charge of the electric power storage device is made high in the travel section in the CS mode, there is the possibility that the high state of charge of the electric power storage device cannot sufficiently be consumed in the travel section in the CD mode to the destination. In consideration of the above, the same control as that in the CS mode in the first control may be executed in the case where the current location is not on the controlled-access highway in the CS mode in the second control.

Furthermore, in the hybrid vehicle of the disclosure, the controller may be configured to execute the same control as that in the CS mode in the first control in the case where the current location is in a congested section in the CS mode in the second control. When the current location is in the congested section, it is considered that the travel load is low and there is the low possibility that the larger amount of the energy of the electric power storage device than expected is consumed in the travel sections in the CS mode and the CD mode. Accordingly, in the case where the state of charge of the electric power storage device is made high in the travel section in the CS mode, there is the possibility that the high state of charge of the electric power storage device cannot sufficiently be consumed in the travel section in the CD mode to the destination. In consideration of the above, the same control as that in the CS mode in the first control may be executed in the case where the current location is in the congested section in the CS mode in the second control.

BRIEF DESCRIPTION OF THE DRAWINGS

Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a configuration diagram that schematically shows a configuration of a hybrid vehicle 20 as an embodiment of the disclosure;

FIG. 2 is a flowchart of an example of a processing routine that is executed by a HVECU 70;

FIG. 3 is a flowchart of an example of a processing routine in a modified example;

FIG. 4 is a flowchart of an example of a processing routine in another modified example;

FIG. 5 is a flowchart of an example of a processing routine in yet another modified example;

FIG. 6 is a flowchart of an example of a processing routine in further another modified example;

FIG. 7 is a configuration diagram that schematically shows a configuration of a hybrid vehicle 120 in even further another modified example; and

FIG. 8 is a configuration diagram that schematically shows a configuration of a hybrid vehicle 220 in even further another modified example.

DETAILED DESCRIPTION OF EMBODIMENTS

Next, a mode for carrying out the disclosure will be described by using an embodiment.

FIG. 1 is a configuration diagram that schematically shows a configuration of a hybrid vehicle 20 as an embodiment of the disclosure. As shown in FIG. 1, the hybrid vehicle 20 of the embodiment includes an engine 22, a planetary gear 30, motors MG1 MG2, inverters 41, 42, a battery 50 as an electric power storage device, a charger 60, a navigation system 90, and a hybrid electronic control unit (hereinafter referred to as a "HVECU") 70.

The engine 22 is configured as an internal combustion engine that uses fuel such as gasoline or diesel fuel to output power, and is connected to a carrier of the planetary gear 30 via a damper 28. An operation of this engine 22 is controlled by an engine electronic control unit (hereinafter referred to as an "engine ECU") 24.

Although not shown, the engine ECU 24 is configured as a microprocessor having a CPU as a central component and includes, in addition to the CPU, ROM that stores processing programs, RAM that temporarily stores data, input/output ports, and a communication port. The engine ECU 24 receives signals that are required to control the operation of the engine 22 from various sensors via the input port, and one example of the signal is a crank angle θ_{cr} from a crank position sensor 23a that detects a rotational position of a crankshaft 26 of the engine 22. The engine ECU 24 outputs various control signals used to control the operation of the engine 22 via the output port. The engine ECU 24 is connected to the HVECU 70 via the communication port. The engine ECU 24 calculates a speed N_e of the engine 22 on the basis of the crank angle θ_{cr} from the crank position sensor 23a.

The planetary gear 30 is configured as a planetary gear mechanism of a single pinion type. A rotor of the motor MG1 is connected to a sun gear of the planetary gear 30. A driveshaft 36 that is coupled to drive wheels 39a, 39b via a differential gear 38 is connected to a ring gear of the planetary gear 30. As described above, the crankshaft 26 of the engine 22 is connected to the carrier of the planetary gear 30 via the damper 28.

The motor MG1 is configured as a synchronous generator-motor, for example, and, as described above, the rotor thereof is connected to the sun gear of the planetary gear 30. The motor MG2 is configured as a synchronous generator-motor, for example, and a rotor thereof is connected to the driveshaft 36. The inverters 41, 42 are used to drive the motors MG1, MG2, respectively, and are each connected to the battery 50 via an electric power line 54. A smoothing capacitor 57 is attached to each of the electric power lines 54. The motors MG1, MG2 are rotationally driven when plural switching elements, which are not shown, of the inverters 41, 42 are subjected to switching control by a motor electronic control unit (hereinafter referred to as a "motor ECU") 40.

Although not shown, the motor ECU 40 is configured as a microprocessor having a CPU as a central component and

5

includes, in addition to the CPU, ROM that stores processing programs, RAM that temporarily stores data, input/output ports, and a communication port. The motor ECU **40** receives signals that are required to control driving of the motors MG1, MG2 from various sensors via the input port, and examples of the signals are rotational positions θ_{m1} , θ_{m2} from rotational position detection sensors **43**, **44** that respectively detect rotational positions of the rotors of the motors MG1, MG2 and phase currents I_{u1} , I_{v1} , I_{u2} , I_{v2} from current sensors **45u**, **45v**, **46u**, **46v**, each of which detects a current flowing through a phase of one of the motors MG1, MG2. The motor ECU **40** outputs switching control signals to the plural switching elements of the inverters **41**, **42**, and the like via the output port. The motor ECU **40** is connected to the HVECU **70** via the communication port. The motor ECU **40** calculates electrical angles θ_{e1} , θ_{e2} , angular velocities ω_{m1} , ω_{m2} , and rotational speeds N_{m1} , N_{m2} of the motors MG1, MG2 on the basis of the rotational positions θ_{m1} , θ_{m2} of the rotors of the motors MG1, MG2 from the rotational position detection sensors **43**, **44**.

The battery **50** is configured as a lithium-ion secondary battery or a nickel-metal hydride secondary battery, for example, and is connected to the electric power lines **54**. This battery **50** is managed by a battery electronic control unit (hereinafter referred to as a "battery ECU") **52**.

Although not shown, the battery ECU **52** is configured as a microprocessor having a CPU as a central component and includes, in addition to the CPU, ROM that stores processing programs, RAM that temporarily stores data, input/output ports, and a communication port. The battery ECU **52** receives signals that are required to manage the battery **50** from various sensors via the input port. Examples of the signals received by the battery ECU **52** are a voltage V_b of the battery **50** from a voltage sensor **51a** that is attached between terminals of the battery **50**, a current I_b of the battery **50** from a current sensor **51b** that is attached to the output terminal of the battery **50**, and a temperature T_b of the battery **50** from a temperature sensor **51c** that is attached to the battery **50**. The battery ECU **52** is connected to the HVECU **70** via the communication port. The battery ECU **52** calculates a state of charge SOC, an amount of consumable energy E_b , input/output limits W_{in} , W_{out} of the battery **50**. The state of charge SOC of the battery **50** is a ratio of an electric power amount that can be discharged from the battery **50** to total capacity of the battery **50**, and is calculated on the basis of an integrated value of the current I_b of the battery **50** from the current sensor **51b**. The amount of the consumable energy E_b of the battery **50** is acquired by converting a difference (SOC-S_{min}) between the state of charge SOC of the battery **50** and a threshold S_{min} to energy, and is calculated as a product of the difference (SOC-S_{min}) and the total capacity. As the threshold S_{min}, for example, 20%, 25%, 30%, or the like is used. The input/output limits W_{in} , W_{out} of the battery **50** are allowable charge/discharge electric power that can be stored/discharged in/from the battery **50**, and are calculated on the basis of the state of charge SOC of the battery **50** and the temperature T_b of the battery **50** from the temperature sensor **51c**.

The charger **60** is connected to the electric power lines **54** and is configured to be able to charge the battery **50** by the electric power from an external power supply when an electric power plug **61** is connected to the external power supply such as a household power supply or an industrial power supply at a charge point such as a house or a charging station.

6

The navigation system **90** includes: a main body **92** in which a control unit having a storage medium such as a hard disk that stores map information and the like, input/output ports, and a communication port is installed; a GPS antenna **94a** that receives information on a current location of a host vehicle; a VICS® antenna **94b** that receives traffic jam information, regulation information, disaster information, and the like from an information center; and a touch-screen display **96** that displays various types of the information such as the information on the current location of the host vehicle and a travel plan route to a destination and to which a user can input various commands. Here, in the map information, service information (for example, sightseeing information, parking lots, and the like), road information of each travel section (for example, between traffic lights, between intersections, and the like), and the like are stored as a database. The road information includes distance information, road width information, lane number information, area information (urban or rural), type information (a public road or a controlled-access highway), gradient information, a legal speed, the number of the traffic lights, and the like. The navigation system **90** is connected to the HVECU **70** via the communication port.

When the user operates the display **96** to set the destination, the main body **92** of this navigation system **90** sets the travel plan route from the current location of the host vehicle to the destination on the basis of the map information stored in the main body **92**, the current location of the host vehicle from the GPS antenna **94a**, and the destination, shows the set travel plan route on the display **96**, and provides route guidance. In addition, the navigation system **90** estimates a travel load in each of the travel sections of the travel plan route when setting the travel plan route to the destination. The travel load in each of the travel sections is estimated on the basis of the road information (for example, the distance information, the type information, the gradient information, the legal speed, and the like).

Although not shown, the HVECU **70** is configured as a microprocessor having a CPU as a central component and includes, in addition to the CPU, ROM that stores processing programs, RAM that temporarily stores data, input/output ports, and a communication port. The HVECU **70** receives signals from various sensors via the input port. Examples of the signals received by the HVECU **70** are an ignition signal from an ignition switch **80** and a shift position SP from a shift position sensor **82** that detects an operation position of a shift lever **81**. Further examples of the signals are an accelerator operation amount Acc from an accelerator position sensor **84** that detects a depression amount of an accelerator pedal **83**, a brake pedal position BP from a brake pedal position sensor **86** that detects a depression amount of a brake pedal **85**, and a vehicle speed V from a vehicle speed sensor **88**. The HVECU **70** outputs control signals to the charger **60** via the output port. As described above, the HVECU **70** is connected to the engine ECU **24**, the motor ECU **40**, the battery ECU **52**, and the navigation system **90** via the communication port.

In the hybrid vehicle **20** of the embodiment that is configured as described above, the charger **60** is controlled such that, in the case where the electric power plug **61** is connected to the external power supply when a system is shut off (the system is stopped) and the vehicle is stopped at the charge point such as the house or the charging station, the battery **50** can be charged by using the electric power from the external power supply.

In addition, the hybrid vehicle **20** of the embodiment makes hybrid travel (HV travel) or electric travel (EV travel)

in a charge depleting (CD) mode or a charge sustaining (CS) mode. Here, in the HV travel, the hybrid vehicle **20** travels together with the operation of the engine **22**. In the EV travel, the hybrid vehicle **20** travels without the operation of the engine **22**. The CD mode is a mode in which the state of charge SOC of the battery **50** is reduced. The CS mode is a mode in which the state of charge SOC of the battery **50** is maintained within a management range including a control center SOC*. In the CD mode, the EV travel is more likely to be made than the HV travel when compared to the CS mode.

In the HV travel, the HVECU **70** sets requested torque Td^* that is requested for the driveshaft **36** on the basis of the accelerator operation amount Acc and the vehicle speed V , and calculates requested power Pd^* that is requested for the driveshaft **36** by multiplying the set requested torque Td^* by a rotational speed Nd of the driveshaft **36** (a rotational speed $Nm2$ of the motor **MG2**). Next, the HVECU **70** sets requested charge/discharge electric power Pb^* of the battery **50** (having a positive value when the electric power is discharged from the battery **50**) such that a value (SOC-SOC*) acquired by subtracting a target state of charge SOC* from the state of charge SOC of the battery **50** approximates a value of 0, and sets requested power Pe^* that is requested for the engine **22** by subtracting the requested charge/discharge electric power Pb^* of the battery **50** from the requested power Pd^* . Then, the HVECU **70** sets a target speed Ne^* and target torque Te^* of the engine **22** and torque commands $Tm1^*$, $Tm2^*$ of the motors **MG1**, **MG2** such that the requested power Pe^* is output from the engine **22** and the requested torque Td^* is output from the driveshaft **36** within a range of the input/output limits Win , $Wout$ of the battery **50**. Thereafter, the HVECU **70** sends the target speed Ne^* and the target torque Te^* of the engine **22** to the engine ECU **24** and sends the torque commands $Tm1^*$, $Tm2^*$ of the motors **MG1**, **MG2** to the motor ECU **40**. When receiving the target speed Ne^* and the target torque Te^* of the engine **22**, the engine ECU **24** executes operation control (intake air amount control, fuel injection control, ignition control, and the like) of the engine **22** such that the engine **22** is operated on the basis of the target speed Ne^* and the target torque Te^* . When receiving the torque commands $Tm1^*$, $Tm2^*$ of the motors **MG1**, **MG2**, the motor ECU **40** execute drive control of the motors **MG1**, **MG2** (more specifically, the switching control of the plural switching elements of the inverters **41**, **42**) such that the motors **MG1**, **MG2** are driven in accordance with the torque commands $Tm1^*$, $Tm2^*$.

In this HV travel, in the case where the requested torque Td^* becomes equal to or lower than a stop threshold Tsp and the requested power Pe^* becomes equal to or lower than a stop threshold Psp in a state where the state of charge SOC of the battery **50** is higher than a threshold Sch , it is determined that a stop condition of the engine **22** is satisfied. Consequently, the operation of the engine **22** is stopped, and the hybrid vehicle **20** is shifted to the EV travel. Here, the threshold Sch is defined as a value that is lower than the above-described threshold $Smin$, and a value such as 5%, 7%, or 10% that is lower than the threshold $Smin$ is used, for example. Here, as the stop threshold Tsp , a CD mode stop threshold $Tspcd$ is used in the CD mode, and a CS mode stop threshold $Tspcs$ that is lower than the CD mode stop threshold $Tspcd$ is used in the CS mode. As the stop threshold Psp , a CD mode stop threshold $Pspcd$ is used in the CD mode, and a CS mode stop threshold $Pspcs$ that is lower than the CD mode stop threshold $Pspcd$ is used in the CS mode. In the embodiment, the CS mode stop thresholds $Tspcs$, $Pspcs$ are set by a processing routine, which will be

described below, and constant values are used for the CD mode stop thresholds $Tspcd$, $Pspcd$.

In the EV travel, the HVECU **70** sets the requested torque Td^* on the basis of the accelerator operation amount Acc and the vehicle speed V , sets the torque command $Tm1^*$ of the motor **MG1** to a value 0, sets the torque command $Tm2^*$ of the motor **MG2** such that the requested torque Td^* is output to the driveshaft **36** within the range of the input/output limits Win , $Wout$ of the battery **50**, and sends the torque commands $Tm1^*$, $Tm2^*$ of the motors **MG1**, **MG2** to the motor ECU **40**. The drive control of the motors **MG1**, **MG2** by the motor ECU **40** has been described above.

In this EV travel, in the case where the state of charge SOC of the battery **50** becomes equal to or lower than the above-described threshold Sch , the requested torque Td^* becomes higher than a start threshold Tst , and the requested power Pe^* that is calculated in the same manner as that in the HV travel becomes equal to or higher than a start threshold Pst , it is determined that a start condition of the engine **22** is satisfied. Consequently, the engine **22** is started, and the hybrid vehicle **20** is shifted to the HV travel. Here, as the start threshold Tst , a CD mode start threshold $Tstcd$ that is higher than the CD mode stop threshold $Tspcd$ is used in the CD mode, and a CS mode start threshold $Tstcs$ that is higher than the CS mode stop threshold $Tspcs$ and is lower than the CD mode start threshold $Tstcd$ is used in the CS mode. As the start threshold Pst , a CD mode start threshold $Pstcd$ that is higher than the CD mode stop threshold $Pspcd$ is used in the CD mode, and a CS mode start threshold $Pstcs$ that is higher than the CS mode stop threshold $Pspcs$ and lower than the CD mode start threshold $Pstcd$ is used in the CS mode. In the embodiment, the CS mode start thresholds $Tstcs$, $Pstcs$ are set by the processing routine, which will be described below, and constant values are used for the CD mode start thresholds $Tstcd$, $Pstcd$.

Next, a description will be made on an operation of the hybrid vehicle **20** in the embodiment that is configured as described so far. FIG. 2 is a flowchart of an example of the processing routine that is executed by the HVECU **70**. This routine is repeatedly executed.

When the processing routine in FIG. 2 is executed, the HVECU **70** initially determines whether travel assistance control can be executed (step S100). Here, the travel assistance control is control in which the hybrid vehicle **20** makes the HV travel or the EV travel in the CD mode or the CS mode in accordance with a travel plan in which the CD mode or the CS mode is assigned to each of the travel sections of the travel plan route to the destination. In the embodiment, in the case where the navigation system **90** provides the route guidance of the travel plan route and the state of charge SOC of the battery **50** is higher than the above-described threshold $Smin$, it is determined that the travel assistance control can be executed. On the other hand, in the case where the navigation system **90** does not provide the route guidance of the travel plan route and the state of charge SOC of the battery **50** is equal to or lower than the threshold $Smin$, it is determined that the travel assistance control cannot be executed. Note that the route guidance of the travel plan route by the navigation system **90** is initiated when the travel plan route to the destination is set, and is thereafter terminated when the host vehicle arrives at the destination, the user deletes the destination, the ignition switch **80** is turned off, or the like.

If it is determined in step S100 that the travel assistance control cannot be executed, the CS mode start thresholds $Tstcs$, $Pstcs$ are set to basic values $Tstcs1$, $Pstcs1$ (step S110), the CS mode stop thresholds $Tspcs$, $Pspcs$ are set to basic

values T_{spcs1} , P_{spcs1} (step S112), basic control is executed (step S120), and this routine is terminated.

Here, the basic control is control in which the hybrid vehicle 20 makes the HV travel or the EV travel in the CD mode or the CS mode on the basis of the state of charge SOC of the battery 50. In the case where the travel assistance control cannot be executed due to absence of the route guidance of the travel plan route, as execution of the basic control, the hybrid vehicle 20 travels in the CD mode after the system is activated and before the state of charge SOC of the battery 50 becomes equal to or lower than the threshold S_{min} . Thereafter, at the time when the state of charge SOC of the battery 50 becomes equal to or lower than the threshold S_{min} onward, the hybrid vehicle 20 travels in the CS mode. Meanwhile, in the case where the route guidance of the travel plan route is provided but the travel assistance control cannot be executed due to a reason that the state of charge SOC of the battery 50 is equal to or lower than the threshold S_{min} , as the execution of the basic control, the hybrid vehicle 20 travels in the CS mode.

If it is determined in step S100 that the travel assistance control can be executed, the CD mode or the CS mode is assigned to each of the travel sections of the travel plan route to the destination so as to create (update) the travel plan (step S130 to S220). Hereinafter, the creation of the travel plan to the destination will be described. Hereinafter, the travel section to which the CD mode is assigned will be referred to as a "CD mode section", and the travel section to which the CS mode is assigned will be referred to as a "CS mode section".

When the travel plan to the destination is created, amounts of the amounts of the energy to be consumed $E[1]$ to $E[n]$ in the travel sections of the travel plan route to the destination are initially estimated (step S130), and a total amount of the energy to be consumed E_{sum} up to the destination is estimated as a sum of the amounts of the estimated energy to be consumed $E[1]$ to $E[n]$ in the travel sections (step S140). Here, the value 1 to the value n are numbers that represents the travel sections of the travel plan route to the destination from the current location of the host vehicle. In the processing in step S130, the HVECU 70 receives travel loads $R[1]$ to $R[n]$ in the travel sections of the travel plan route to the destination via the communication with the navigation system 90, and estimates the amounts of the energy to be consumed $E[1]$ to $E[n]$ in the travel section on the basis of the received travel loads $R[1]$ to $R[n]$ in the travel sections. More specifically, the HVECU 70 estimates the larger amounts of the energy to be consumed $E[1]$ to $E[n]$ of the travel sections as the travel loads $R[1]$ to $R[n]$ in the travel sections are increased.

Next, the HVECU 70 receives the amount of the consumable energy E_b of the battery 50 via the communication with the battery ECU 52 (step S150), and compares the total amount of the energy to be consumed E_{sum} up to the destination with the amount of the consumable energy E_b of the battery 50 (step S160). The processing in step S160 is processing to determine whether the hybrid vehicle 20 can travel to the destination only by the EV travel.

If the total amount of the energy to be consumed E_{sum} up to the destination is equal to or smaller than the amount of the consumable energy E_b of the battery 50 in step S160, it is determined that the hybrid vehicle 20 can travel to the destination only by the EV travel, the CD mode is assigned to all the travel sections of the travel plan route to the destination, and the travel plan is thereby created (updated) (step S170).

If the total amount of the energy to be consumed E_{sum} up to the destination is larger than the amount of the consumable energy E_b of the battery 50 in step S160, it is determined that the hybrid vehicle 20 cannot travel to the destination only by the EV travel, and target travel sections are set from the travel sections of the travel plan route to the destination (step S180). In this processing, of the travel sections, the travel section to which the CD mode is not assigned and in which the travel load is the lowest is set as the target travel section.

Next, the CD mode is assigned to the set target travel sections (step S190), and a total amount of energy to be consumed E_{cdsum} in all the CD mode sections is estimated (step S200). In the processing in step S200, of the amounts of the energy to be consumed $E[1]$ to $E[n]$ of the travel sections of the travel plan route to the destination, a sum of the amounts of the energy to be consumed in all the CD mode sections is calculated as the total amount of the energy to be consumed E_{cdsum} .

Once the total amount of the energy to be consumed E_{cdsum} is estimated just as described, the estimated total amount of the energy to be consumed E_{cdsum} is compared with the amount of the consumable energy E_b of the battery 50 (step S210). This processing is processing to determine whether the hybrid vehicle 20 can travel all the CD mode sections only by the EV travel. If the total amount of the energy to be consumed E_{cdsum} is equal to or smaller than the amount of the consumable energy E_b of the battery 50 in step S210, it is determined that the hybrid vehicle 20 can travel all the CD mode sections only by the EV travel, and the processing returns to step S180. Just as described, the CD mode is assigned to the travel sections of the travel plan route to the destination in an ascending order of the travel loads.

If the total amount of the energy to be consumed E_{cdsum} is larger than the amount of the consumable energy E_b of the battery 50 in step S210, it is determined that the hybrid vehicle 20 cannot travel in all the CD mode sections only by the EV travel, and the CS mode is assigned to the current target travel section and the remaining travel sections (step S220). Because it is considered in step S160 that the total amount of the energy to be consumed E_{sum} up to the destination is larger than the amount of the consumable energy E_b of the battery 50, the CS mode is assigned to at least one of the travel sections.

In the case where the travel plan to the destination is created (updated) by the processing in steps S130 to S220 as described above, the CS mode start thresholds T_{stcs} , P_{stcs} are set to lower values T_{stcs2} , P_{stcs2} than the basic values T_{stcs1} , P_{stcs1} (the values in the basic control) (step S230), the CS mode stop thresholds T_{spcs} , P_{spcs} are set to lower values T_{spcs2} , P_{spcs2} than the basic values T_{spcs1} , P_{spcs1} (the values in the basic control) (step S232), and the travel assistance control (the control in which the engine 22 and the motors MG1, MG2 are controlled for the travel following the travel plan) (step S240).

The CS mode start thresholds T_{stcs} , P_{stcs} are set to be smaller in the travel assistance control than in the basic control. In this way, the start condition of the engine 22 is more likely to be satisfied in the CS mode in the travel assistance control than in the CS mode in the basic control. Thus, shifting of the hybrid vehicle 20 from the EV travel to the HV travel is promoted. In addition, the CS mode stop thresholds T_{spcs} , P_{spcs} are set to be lower in the travel assistance control than in the basic control. In this way, the stop condition of the engine 22 is less likely to be satisfied in the CS mode in the travel assistance control than in the CS

mode in the basic control. Thus, shifting of the hybrid vehicle **20** from the EV travel to the HV travel is impeded (continuation of the HV travel is promoted). Furthermore, in the HV travel, the value (SOC-SOC*) that is acquired by subtracting the target state of charge SOC* from the state of charge SOC of the battery **50** is controlled to approximate the value 0. Thus, the state of charge SOC of the battery **50** is likely to become higher in the HV travel than in the EV travel. From what have been described so far, it can be said that, in the case where the CS mode start thresholds Tstcs, Pstcs and the CS mode stop thresholds Tspcs, Pspcs are set to be lower in the travel assistance control than in the basic control, the state of charge SOC of the battery **50** can be made high in the CS mode sections in the travel assistance control when compared to the case where the CS mode start thresholds Tstcs, Pstcs and the CS mode stop thresholds Tspcs, Pspcs in the travel assistance control are set to be equal to those in the basic control. In this way, it is possible to suppress the amount of the consumable energy Eb of the battery **50**, which can be consumed in the following CD mode section in the travel assistance control, from becoming smaller than expected. As a result, it is possible to suppress the state of charge SOC of the battery **50** from becoming equal to or lower than the threshold Smin in the CD mode section in the travel assistance control and thereby suppress the execution of the travel assistance control from being inhibited.

Next, it is determined whether read-ahead information has been updated via the communication with the navigation system **90** (step S250). Here, examples of the read-ahead information are the road information and the traffic jam information from the current location of the host vehicle to a destination-side point by a specified distance (for example, approximately several kilometers to ten several kilometers) therefrom in the travel plan route. Such read-ahead information is updated when the travel plan route is changed after the last update of the read-ahead information, when a specified time (for example, approximately several tens of seconds to several minutes) has elapsed since the last update of the read-ahead information, when the hybrid vehicle **20** has traveled for a specified distance (for example, approximately several hundreds of meters to several kilometers) since the last update of the read-ahead information, or the like. If it is determined that the read-ahead information has not been updated, the processing returns to step S230. If it is determined that the read-ahead information has been updated, this routine is terminated.

In the hybrid vehicle **20** of the embodiment that has been described so far, the CS mode start thresholds Tstcs, Pstcs and the CS mode stop thresholds Tspcs, Pspcs are set to be lower in the travel assistance control than in the basic control. In this way, the state of charge SOC of the battery **50** can be made high in the CS mode sections in the travel assistance control when compared to the case where the CS mode start thresholds Tstcs, Pstcs and the CS mode stop thresholds Tspcs, Pspcs in the travel assistance control are set to be equal to those in the basic control. As a result, it is possible to suppress the amount of the consumable energy Eb of the battery **50**, which can be consumed in the following CD mode sections in the travel assistance control, from becoming smaller than expected.

In the hybrid vehicle **20** of the embodiment, as described by using the processing routine in FIG. 2, the CS mode start thresholds Tstcs, Pstcs and the CS mode stop thresholds Tspcs, Pspcs are changed on the basis of whether the current control is the basic control or the travel assistance control. However, on the basis of whether the current control is the

basic control or the travel assistance control, only one or some of the CS mode start threshold Tstcs, the CS mode start threshold Pstcs, the CS mode stop threshold Tspcs, and the CS mode stop threshold Pspcs (for example, the CS mode start thresholds Tstcs, Pstcs) may be changed.

As described above, in the processing routine in FIG. 2 and the modified example thereof, at least one of the CS mode start threshold Tstcs, the CS mode start threshold Pstcs, the CS mode stop threshold Tspcs, and the CS mode stop threshold Pspcs is changed on the basis of whether the current control is the basic control or the travel assistance control. However, instead of the above, or in addition to the above, at least one of the target state of charge SOC*, the input limit Win, and the output limit Wout of the battery **50** may be changed on the basis of whether the current control is the basic control or the travel assistance control.

FIG. 3 is a flowchart of an example of a processing routine that is executed when the target state of charge SOC* and the input/output limits Win, Wout of the battery **50** are changed on the basis of whether the current control is the basic control or the travel assistance control. The processing routine in FIG. 3 is the same as the processing routine in FIG. 2 except for a point that processing in steps S110b, S112b, S230b, and S232b is executed instead of the processing in steps S110, S112, S230, and S232. Thus, the same processing in the processing routine in FIG. 3 as that in the processing routine in FIG. 2 will be denoted by the same step numbers, and the detailed description thereon will not be made.

In the processing routine in FIG. 3, if it is determined in step S100 that the travel assistance control cannot be executed, the target state of charge SOC* of the battery **50** is set to a basic value S1 (step S110b), the input limit Win of the battery **50** is set to a negative basic value Win1, and the output limit Wout of the battery **50** is set to a positive basic value Wout1 (step S112b). Then, the basic control is executed (step S120), and this routine is terminated.

Once the travel plan to the destination is created (updated) by the processing in steps S130 to S220, the target state of charge SOC* of the battery **50** is set to a higher value S2 than the basic value S1 (step S230b), the input limit Win of the battery **50** is set to a negative value Wing that is lower (higher as an absolute value) than the negative basic value Win1, and the output limit Wout of the battery **50** is set to a positive value Wout2 that is lower than the positive basic value Wout1 (step S232b). Then, the travel assistance control is executed (step S240), and the processing proceeds to above-described step S250.

With such control, in the CS mode sections in the travel assistance control, charged/discharged electric power of the battery **50** can be increased to the charged side (reduced to the discharged side), and the state of charge SOC of the battery **50** can be made high when compared to the case where the target state of charge SOC* and the input/output limits Win, Wout of the battery **50** in the travel assistance control are set to be equal to those in the basic control. As a result, it is possible to suppress the amount of the consumable energy Eb of the battery **50**, which can be consumed in the following CD mode sections in the travel assistance control, from becoming smaller than expected.

In the hybrid vehicle **20** of the embodiment, the HVECU **70** executes the processing routine in FIG. 2. However, instead of the processing routine in FIG. 2, the HVECU **70** may execute a processing routine in FIG. 4. The processing routine in FIG. 4 is the same as the processing routine in FIG. 2 except for a point that processing in steps S300 to S322 are added. Thus, the same processing in the processing

routine in FIG. 4 as that in the processing routine in FIG. 2 will be denoted by the same step numbers, and the detailed description thereon will not be made.

In the processing routine in FIG. 4, once creating (updating) the travel plan to the destination by the processing in steps S130 to S220, the HVECU 70 receives a distance L_d to the destination (step S300) and compares the received distance L_d to the destination with a threshold L_{dref} (step S310). Here, as the threshold L_{dref} , 1 km, 2 km, 3 km, or the like is used, for example.

If the distance L_d to the destination is equal to or longer than the threshold L_{dref} in step S310, the CS mode start thresholds T_{stcs} , P_{stcs} are set to the values T_{stcs2} , P_{stcs2} (step S230), and the CS mode stop thresholds T_{spcs} , P_{spcs} are set to the values T_{spcs2} , P_{spcs2} (step S232). Then, the travel assistance control is executed (step S240), and the processing proceeds to above-described step S250.

If the distance L_d to the destination is shorter than the threshold L_{dref} in step S310, the CS mode start thresholds T_{stcs} , P_{stcs} are set to the basic values T_{stcs1} , P_{stcs1} (step S320), and the CS mode stop thresholds T_{spcs} , P_{spcs} are set to the basic values T_{spcs1} , P_{spcs1} (step S322). Then, the travel assistance control is executed (step S240), and the processing proceeds to above-described step S250.

In the case where the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} are reduced to promote the HV travel in the CS mode sections and to further increase the amount of the consumable energy E_b of the battery 50 when the distance L_d to the destination is short, there is a possibility that the increased amount of the consumable energy E_b cannot sufficiently be consumed in the CD mode sections to the destination (the certain large amount of the consumable energy E_b remains on arrival at the destination). In view of such a circumstance, as in this modified example, in the case where the distance L_d to the destination is shorter than the threshold L_{dref} when the travel assistance control is executed, it is considered to set the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} to be equal to those in the basic control.

In this modified example, the HVECU 70 executes the processing routine in FIG. 4. However, instead of the processing routine in FIG. 4, the HVECU 70 may execute a processing routine in FIG. 5 or FIG. 6. Hereinafter, the processing routines in FIG. 5 and FIG. 6 will sequentially be described.

Initially, the processing routine in FIG. 5 will be described. The processing routine in FIG. 5 is the same as the processing routine in FIG. 4 except for a point that processing in steps S300*b* and S310*b* is executed instead of the processing in steps S300 and 310. Thus, the same processing in the processing routine in FIG. 5 as that in the processing routine in FIG. 4 will be denoted by the same step numbers, and the detailed description thereon will not be made.

In the processing routine in FIG. 5, once creating (updating) the travel plan to the destination by the processing in steps S130 to S220, the HVECU 70 receives the current location of the host vehicle and the road information via the communication with the navigation system 90 (step S300*b*), and determines whether the current location of the host vehicle is on the controlled-access highway on the basis of the received current location of the host vehicle and the received road information (step S310*b*). If the HVECU 70 determines that the current location of the host vehicle is on the controlled-access highway, the processing proceeds to above-described step S230. On the other hand, if the

HVECU 70 determines that the current location of the host vehicle is not on the controlled-access highway (is on the public road), the processing proceeds to above-described step S320.

When the current location of the host vehicle is on the public road, it is considered that the travel load is low and there is a low possibility that the larger amount of the consumable energy E_b of the battery 50 than expected is consumed in the CS mode sections and the CD mode sections in comparison with the case where the current location of the host vehicle is on the controlled-access highway. Accordingly, in the case where the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} are reduced to promote the HV travel in the CS mode sections, the amount of the consumable energy E_b of the battery 50 is likely to become large in the CS mode section, and thus there is a possibility that the large amount of the consumable energy E_b cannot sufficiently be consumed in the CD mode sections to the destination (the certain large amount of the consumable energy E_b remains on arrival at the destination). In view of such a circumstance, as in this modified example, it is considered to set the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} in the travel assistance control to be equal to those in the basic control when the distance L_d to the destination is shorter than the threshold L_{dref} . In view of such a circumstance, as in this modified example, in the case where the current location of the host vehicle is not on the controlled-access highway when the travel assistance control is executed, it is considered to set the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} to be equal to those in the basic control.

In the processing routine in FIG. 5, in the case where the current location of the host vehicle is not on the controlled-access highway (is on the public road) during the travel assistance control, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} are set to be the equal values to those in the basic control. However, in the case where the current location of the host vehicle is not on the controlled-access highway (is on the public road) but on a particular road such as an urban road, a narrow street, a prefectural road, or a national road during the travel assistance control, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} may be the equal values to those in the basic control.

Next, the processing routine in FIG. 6 will be described. The processing routine in FIG. 6 is the same as the processing routine in FIG. 4 except for a point that processing in steps S300*c* and S310*c* is executed instead of the processing in steps S300 and 310. Thus, the same processing in the processing routine in FIG. 6 as that in the processing routine in FIG. 4 will be denoted by the same step numbers, and the detailed description thereon will not be made.

In the processing routine in FIG. 6, once creating (updating) the travel plan to the destination by the processing in steps S130 to S220, the HVECU 70 receives the current location of the host vehicle and the read-ahead information via the communication with the navigation system 90 (step S300*c*), and determines whether the current location of the host vehicle is in a congested section on the basis of the received current location of the host vehicle and the received read-ahead information (step S310*c*). Then, if the HVECU 70 determines that the current location of the host vehicle is not in the congested section, the processing proceeds to above-described step S230. On the other hand, if the HVECU 70 determines that the current location of the host

vehicle is in the congested section, the processing proceeds to above-described step S320.

When the current location of the host vehicle is in the congested section, it is considered that the travel load is low and there is the low possibility that the larger amount of the consumable energy E_b of the battery **50** than expected is consumed in the CS mode sections and the CD mode sections. Accordingly, in the case where the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} are reduced to promote the HV travel in the CS mode sections, the amount of the consumable energy E_b of the battery **50** is likely to become large in the CS mode section, and thus there is the possibility that the large amount of the consumable energy E_b cannot sufficiently be consumed in the CD mode sections to the destination (the certain large amount of the consumable energy E_b remains on arrival at the destination). In view of such a circumstance, as in this modified example, in the case where the current location of the host vehicle is in the congested section when the travel assistance control is executed, it is considered to set the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} to be equal to those in the basic control.

In each of processing routines in FIG. 4 to FIG. 6, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} in the travel assistance control are changed on the basis of the distance L_d to the destination, whether the current location of the host vehicle is on the controlled-access highway, or whether the current location of the host vehicle is in the congested section. However, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} in the travel assistance control may be changed on the basis of at least two of the above. In such a case, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} in the travel assistance control may be changed (A) when the distance L_d to the destination is equal to or longer than the threshold L_{dref} , the current location of the host vehicle is on the controlled-access highway, and the current location of the host vehicle is not in the congested section or (B) when the distance L_d to the destination is shorter than the threshold L_{dref} , the current location of the host vehicle is not on the controlled-access highway, or the current location of the host vehicle is in the congested section. At the time of (A), the CS mode start thresholds T_{stcs} , P_{stcs} are set to the values T_{stcs2} , P_{stcs2} , and the CS mode stop thresholds T_{spcs} , P_{spcs} are set to the values T_{spcs2} , P_{spcs2} . At the time of (B), the CS mode start thresholds T_{stcs} , P_{stcs} are set to the basic values T_{stcs1} , P_{stcs1} , and the CS mode stop thresholds T_{spcs} , P_{spcs} are set to the basic values T_{spcs1} , P_{spcs1} .

As described above, in the processing routines in FIG. 4 to FIG. 6 and the modified examples of these, the CS mode start thresholds T_{stcs} , P_{stcs} and the CS mode stop thresholds T_{spcs} , P_{spcs} in the travel assistance control are changed on the basis of at least one of the distance L_d to the destination, whether the current location of the host vehicle is on the controlled-access highway, and whether the current location of the host vehicle is in the congested section. However, instead of the above, or in addition to the above, the target state of charge SOC^* , the input limit W_{in} , and the output limit W_{out} of the battery **50** in the travel assistance control may be changed on the basis of at least one of the distance L_d to the destination, whether the current location of the host vehicle is on the controlled-access highway, and whether the current location of the host vehicle is in the congested section.

In the hybrid vehicle **20** of the embodiment, the main body **92** of the navigation system **90** sets the travel plan route to the destination on the basis of the map information stored in the main body **92**, the current location of the host vehicle, and the destination. However, in the case where the hybrid vehicle **20** can communicate with an external system (for example, a cloud server or the like), the external system may set the travel plan route to the destination on the basis of the map information provided in the external system and the current location and the destination from the hybrid vehicle **20**, and may send the travel plan route to the destination to the hybrid vehicle **20**.

In the hybrid vehicle **20** of the embodiment, the HVECU **70** creates (updates) the travel plan on the basis of the travel plan route to the destination. However, in the case where the hybrid vehicle **20** can communicate with the external system, the external system may create (update) the travel plan on the basis of the travel plan route to the destination, and may send the travel plan to the hybrid vehicle **20**.

In the hybrid vehicle **20** of the embodiment, the battery **50** is used as the electric power storage device. However, a capacitor may be used instead of the battery **50**.

The hybrid vehicle **20** of the embodiment includes the engine ECU **24**, the motor ECU **40**, the battery ECU **52**, and the HVECU **70**. However, at least two of these may be configured as single electronic control units.

The hybrid vehicle **20** of the embodiment is configured that the engine **22** and the motor **MG1** are connected to the driveshaft **36**, which is coupled to the drive wheels **39a**, **39b**, via the planetary gear **30**, that the motor **MG2** is connected to the driveshaft **36**, and that the battery **50** is connected to the motors **MG1**, **MG2** via the electric power lines **54**. However, as shown in a hybrid vehicle **120** of a modified example in FIG. 7, a configuration of a so-called single-motor hybrid vehicle in which a motor **MG** is connected to the driveshaft **36**, which is coupled to the drive wheels **39a**, **39b**, via a transmission **130**, in which the engine **22** is connected to the motor **MG** via a clutch **129**, and in which the battery **50** is connected to the motor **MG** via an electric power line may be adopted. Alternatively, as shown in a hybrid vehicle **220** of another modified example in FIG. 8, a configuration of a so-called series hybrid vehicle in which the generator-motor **MG1** is connected to the engine **22**, in which the travel motor **MG2** is connected to the driveshaft **36**, which is coupled to the drive wheels **39a**, **39b**, and in which the battery **50** is connected to the motors **MG1**, **MG2** via electric power lines may be adopted.

In the embodiment, the engine **22** is an example of the “engine”, each of the motors **MG1**, **MG2** is an example of the “motor”, the battery **50** is an example of the “electric power storage device”, and the HVECU **70**, the engine ECU **24**, the motor ECU **40**, and the navigation system **90** are an example of the “controller”.

The mode for carrying out the disclosure has been described so far by using the embodiment. However, the disclosure is not limited to such an embodiment in any respect. Needless to say, the disclosure can be implemented in various modes within the scope that does not depart from the gist of the disclosure.

The disclosure can be used in a hybrid vehicle manufacturing industry and the like.

What is claimed is:

1. A hybrid vehicle comprising:
 - an engine;
 - a motor;

17

an electric power storage device configured to store electric power from the motor and supply electric power to the motor; and
 a controller configured to execute first control when a specified condition is not satisfied and to execute second control when the specified condition is satisfied, the specified condition including such a condition that a destination has been set, the first control being control of the engine and the motor such that the hybrid vehicle travels by switching between a charge depleting mode and a charge sustaining mode, and the second control being control of the engine and the motor such that the hybrid vehicle travels in accordance with a travel plan in which the charge depleting mode or the charge sustaining mode is assigned to each travel section of a travel plan route to the destination, wherein the controller is configured to control the engine and the motor such that a state of charge of the electric power storage device becomes higher in the charge sustaining mode in the second control than in the charge sustaining mode in the first control.

2. The hybrid vehicle according to claim 1, wherein the controller is configured to set a start threshold of the engine to be lower in the charge sustaining mode in the second control than in the charge sustaining mode in the first control.

3. The hybrid vehicle according to claim 1, wherein the controller is configured to set a stop threshold of the engine to be lower in the charge sustaining mode in the second control than in the charge sustaining mode in the first control.

18

4. The hybrid vehicle according to claim 1, wherein in the charge sustaining mode in the second control, the controller executes at least one of increasing a target charged-discharged amount of the electric power storage device to a charged side, increasing allowable charge electric power of the electric power storage device, and reducing allowable discharge electric power of the electric power storage device in comparison with those in the charge sustaining mode in the first control.

5. The hybrid vehicle according to claim 1, wherein the controller is configured to execute the same control as that in the charge sustaining mode in the first control in the case where a distance to the destination is shorter than a specified distance in the charge sustaining mode in the second control.

6. The hybrid vehicle according to claim 1, wherein the controller is configured to execute the same control as that in the charge sustaining mode in the first control in the case where a current location is not on a controlled-access highway in the charge sustaining mode in the second control.

7. The hybrid vehicle according to claim 1, wherein the controller is configured to execute the same control as that in the charge sustaining mode in the first control in the case where the current location is in a congested section in the charge sustaining mode in the second control.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 10,654,466 B2
APPLICATION NO. : 16/273446
DATED : May 19, 2020
INVENTOR(S) : Yuki Ogawa

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

Item (72), inventor 1, city, delete “**Toyota**” and insert --**Toyota-shi Aichi-ken**--, therefor.

In the Specification

In Column 9, Line 32 & 33, delete “**amounts of the amounts of the**” and insert --**amounts of the**--,
therefor.

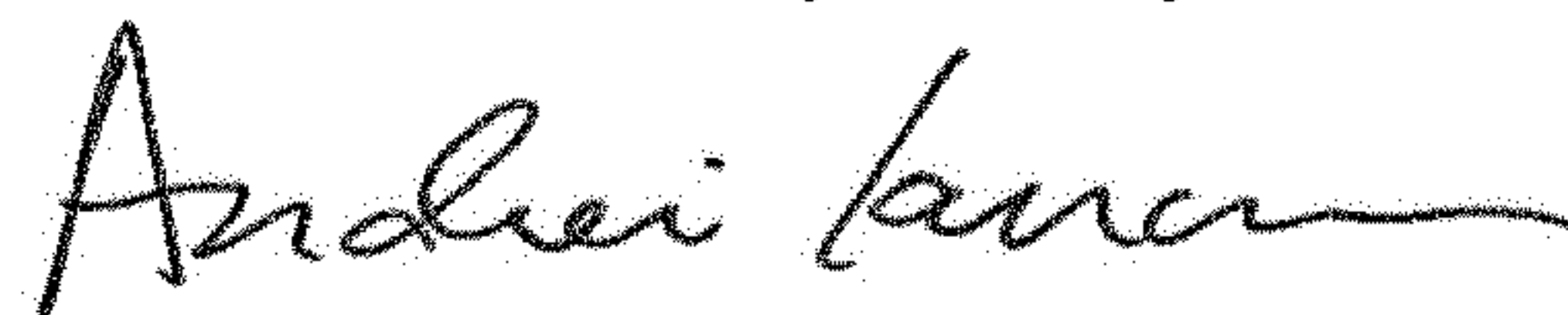
In Column 10, Line 52, delete “**Pspsc**” and insert --**Pspcs**--, therefor.

In Column 13, Line 15, delete “**Pspsc**” and insert --**Pspcs**--, therefor

In Column 15, Line 48, delete “**Pspsc**” and insert --**Pspcs**--, therefor

In Column 16, Line 33, delete “**MG1 MG2**” and insert --**MG1, MG2**--, therefor.

Signed and Sealed this
Fourteenth Day of July, 2020



Andrei Iancu
Director of the United States Patent and Trademark Office